THE MODERN TREATMENT OF DIABETES*

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THE MODERN treatment of diabetes presupposes a knowledge on the part of the physician of the principles of treatment. These principles may be thus enumerated:

PRINCIPLES OF TREATMENT

1. *Weight.* Maintain the patient at or slightly below the ideal body weight.

2. *Number of Feedings.* Divide the day's food allowance into three meals and three supplementary feedings. This will reduce the frequency of insulin reactions. Even diabetic patients who do not require insulin do better on frequent feedings. With protamine insulin, the bedtime feeding is especially necessary.

3. *Protein Requirements.* Provide one gram of protein per kilogram of body weight per twenty-four hours for adults and from two to three grams for children during their rapidly growing periods.

4. *Carbohydrate Requirements.* Provide carbohydrate somewhere in the middle range 120 to 200 grams per twenty-four hours.

5. *Fat Requirements.* Restrict fat to the least possible amount consistent with the maintenance of an ideal body weight. For the purpose of reducing an obese diabetic the fat should be limited to 50 or 60 grams per twenty-four hours and for normal weights should not exceed half the carbohydrate. If the patient is undernourished the fat can exceed this figure.

6. *Vitamin Requirements.* The deficiency in fat soluble vitamins inherent in the low fat diets should be overcome by adding vitamin concentrates to the diet.

7. *Insulin Requirements.* Give enough insulin to keep the urine sugar free without reactions. That means not more than an occasional trace of sugar.

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* Delivered March 18, 1938 in the Friday Afternoon Lecture Series.

8. *Urinalyses.* Control the insulin dosage by means of four separate daily urinalyses, not by a single specimen or a twenty-four hour specimen.

9. *Blood tests.* Blood tests are unnecessary for the control of glycosuria, but *are* necessary to detect a developing hypoglycemia.

10. *Infections* are particularly hazardous to a diabetic. Therefore avoid acute infections and eliminate sources of chronic infection.

These principles constitute a guide for the treatment of diabetes. If they are constantly kept in mind as objectives, the treatment of the disease becomes simplified and will be more successful.

Education of the Patient

The modern treatment of diabetes also presupposes the intelligent cooperation of the patient. The patient or some member of the family should know how to do three things, namely, calculate the diet; test his urine for sugar; give himself insulin.

Calculation of the carbohydrate, protein and fat content of the diet is not the burden it is commonly supposed to be. A well trained patient consumes perhaps five minutes a day at this task. A dietitian can teach a patient in one hour how to calculate his diet. Facility in making the calculations can then be acquired only by daily application to the task on the part of the patient.

For this instruction the services of a trained dietitian is advisable. If no dietitian is available, a nurse or even another diabetic patient can undertake the task. Expense to the patient is negligible compared with that necessary for nursing service in any other medical condition, for only one or two visits are required. The effort involved will be repaid many times by the increased well-being and security of the patient.

The task of calculating the diet should definitely be removed from the shoulders of the physician. It is no more the duty of the physician to calculate his dietary prescriptions than it is to compound his drug prescriptions. When this is fully recognized the general practitioner will approach the new diabetic patient with less perturbation, for the dietary requirements of a diabetic patient can be expressed in a single prescription of three figures. Indeed, the management of a diabetic fits particularly well into the work of a busy practitioner, because, when properly conducted, the patient does the routine work and the physician acts as a consultant at semi-weekly, weekly, or monthly intervals depending

on the severity of the case.

In reviewing in detail the actual management of a diabetic patient it is convenient to discuss the subject under four headings: 1) Diet; 2) Insulin; 3) Complications; 4) Significance of laboratory findings.

Diet

How does one determine the dietetic requirements of a diabetic patient? The task is really very simple. The one food substance that has to be supplied in adequate amount is protein. Existence can be maintained without fat and without carbohydrate, but protein is indispensable to life or even health. *Moreover for a given weight the protein requirement is a constant, regardless of the activity of the patient.* A 145 pound farmer working hard in the field needs no more protein than a bookkeeper of the same weight sitting at his desk, provided the farmer consumes enough carbohydrate and fat to supply the extra calories needed for his increased expenditure of energy. If, however, the carbohydrate and fat of his food is insufficient for his caloric needs, protein will be broken down for its 60 per cent carbohydrate fuel value and consequently his protein requirement will be greater than one gram per kilogram. This is expensive fuel both economically and physiologically. Carbohydrate and fat are protein sparers, and of the two, carbohydrate is safer for a diabetic than fat.

The carbohydrate and fat content of the diet may vary with the requirements of the patient, whether we desire him to gain, lose or maintain weight. Even these calculations may be avoided by adopting a standard beginning diet. This is the practice in most hospitals today.

The beginning diets employed at St. Luke's Hospital are:

Table I

BEGINNING DIABETIC DIETS*

	C	*P*	*F*	*Calories*
Adults	130	65	50	1230
Children 4 years	90	45	20	720
8 years	100	60	30	910
12 years	110	75	40	1100

* These should be increased to maintenance requirements as soon as the diabetes is controlled. A maintenance diet is one which keeps a patient at his ideal weight, and it differs for each individual. The patient's weight is the only reliable guide to his caloric needs.

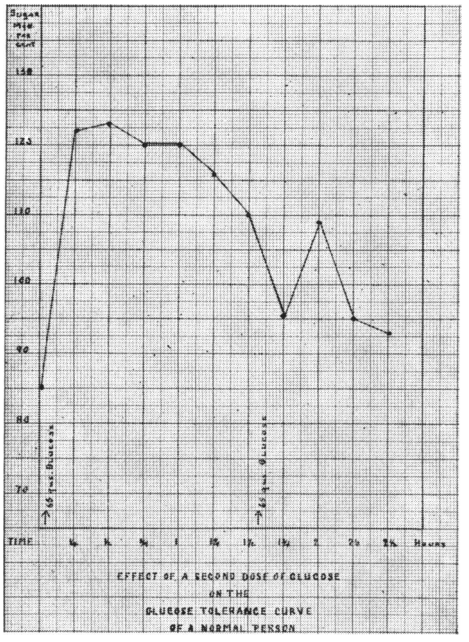

CHART I

These are beginning diets only and are usually less than the patient needs to maintain weight. When the diabetes is controlled on this diet, how are the maintenance requirements of the patient determined? Again it is a simple matter. Instead of making elaborate calculations of the patient's theoretical caloric needs, we simply weigh him once or twice weekly. If he gains weight the diet is too much, if he loses, it is too little, and if his weight remains stationary, it is sufficient. The scale on which the patient is weighed is one of the most essential instruments in the treatment of his diabetes.

The *distribution* of the food throughout the day is equally as important as the amount consumed. *All diabetics should eat between meals.* When employing protamine insulin, these supplementary feedings are especially necessary in order to avoid insulin reactions. Not only do these extra feedings prevent insulin reactions, but, by stimulating the glucose metabolizing apparatus of the body, they enable the body to handle the following meals more effectively.

This stimulating effect of carbohydrate is shown very nicely when a glucose tolerance curve is done with two doses of glucose instead of one. If a second dose of glucose is ingested during the descending arm of

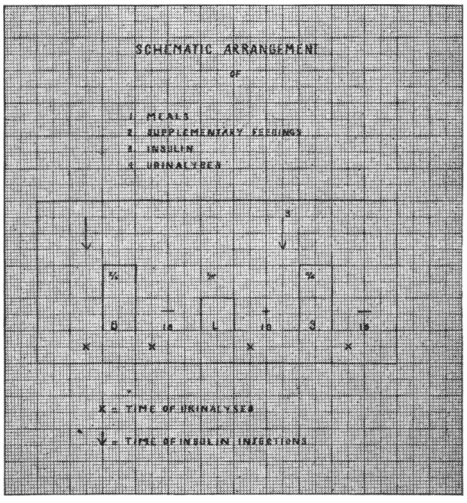

CHART II

the curve it will cause less of an elevation of the blood sugar than the original glucose feeding. (Chart I.)

The fact that carbohydrate given at one time will act as an antidote to insulin while at another it will stimulate insulin production, appears to be contradictory. The reason, of course, is that carbohydrate does not act as a stimulant to insulin production until it has raised the blood sugar to a certain critical level.

In addition to this distribution of the food into six feedings, it has been found that if the three meals themselves be divided in certain definite proportions the maximum carbohydrate load will correspond more closely with the maximum action of insulin. (Chart II.)

It is important, especially at the bedtime feeding, to give the carbohydrate in a slowly absorbing form, such as crackers, milk, cereal or even vegetables, rather than orange juice. Otherwise its buffer effect may take place too rapidly to prevent hypoglycemia in the early morning hours.

It is clear, therefore, that this distribution of food and insulin is not an arbitrary one but is based on a knowledge of the properties of the two types of insulin employed. It is theoretically sound, and yields practical results in diminished glycosuria and fewer insulin reactions.

Fluid Diet

Table II

THE "B & O" DIET

To be used during acute infections, following coma treatment and postoperatively.

C 122—P 21—F 7—Calories 635

7:00 A.M.	Orange juice,	6 ounces
9:00 A.M.	Buttermilk,	6 ounces
11:00 A.M.	Orange juice,	6 ounces
1:00 P.M.	Buttermilk,	6 ounces
3:00 P.M.	Orange juice,	6 ounces
5:00 P.M.	Buttermilk,	6 ounces
7:00 P.M.	Orange juice,	6 ounces
9:00 P.M.	Buttermilk,	6 ounces

Skimmed milk may be substituted for buttermilk, and ginger ale for orange juice with no change in food value.

Water, clear broth and tea or coffee (without cream or sugar) are allowed as desired. Insulin is given by the "color formula" with this diet.

Whenever a diabetic has a fever he must go on a *fluid diet.* Any fluid diet will answer the purpose provided the feedings are given frequently. The one which has been used successfully at St. Luke's Hospital for the past ten years consists of six ounces of buttermilk alternating with six ounces of orange juice every two hours from 7 A.M. to 9 P.M. Additional feedings are given at twelve midnight and 4 A.M. if the patient is awake. If the patient dislikes buttermilk, skimmed milk is given instead. Ginger ale may be substituted for orange juice. This diet should be given whenever the patient from whatever cause cannot take solid food. It is used postoperatively, during acute infections or even for seasickness. This diet, with the night feedings, contains about *130 grams of carbohydrate, 25 grams of protein and practically no fat.* Being low in fat it is an ideal diet for combating acidosis which usually accompanies the conditions for which this diet is prescribed. With this diet insulin is given every two to four hours by the "color formula."

Table III

COLOR FORMULA FOR GIVING INSULIN

The urine is tested with Benedict's qualitative solution every two or three hours and insulin given as follows:

If the test is orange give 15 units of insulin
If the test is yellow give 10 units of insulin
If the test is green give 5 units of insulin
If the test is blue give 4 ounces of orange juice

(Do not continue giving orange juice according to this formula if the test remains blue)

Let it be emphasized again that the management of the diet of a diabetic is extremely simple once we accept the principle that the responsibility of its calculation be transferred from the physician, who is not trained to do this work, to a dietitian or nurse or even another diabetic patient who is trained to do it. The above two types of diet are the only ones that need concern a physician treating a diabetic patient. One diet can be expressed by a prescription of three figures (keeping within the limits laid down in the principles of treatment) and the other is prescribed by the glassful.

Insulin

The introduction of protamine insulin constituted a distinct advance in the therapy of diabetes. But *protamine insulin is not a substitute for standard insulin* except in mild cases. One thing protamine insulin has done is to reduce the necessity for multiple doses of insulin in severe diabetics. For *a mild diabetic*, one dose of protamine insulin alone in the morning is sufficient. *A moderately severe diabetic* will require both protamine and standard insulin before breakfast. *A severe diabetic* needs an additional dose of standard insulin before supper. Young children may require an additional dose of standard insulin at lunch time.

A characteristic effect of protamine insulin, with or without standard insulin, is a flattening out of the twenty-four hour blood sugar curve, eliminating the peaks that occur in mild diabetics not taking insulin and in severe diabetics even with frequent doses of standard insulin (as is shown in the accompanying charts).

The importance of abolishing wide daily fluctuations of the blood sugar is emphasized when we examine its effect on the daily nitrogen balance. Wilder has shown that when the blood sugar rises above the renal threshold there is an increased excretion of nitrogen in the urine with a consequent loss of amino acids. The amino acids are the very substance from which cellular protoplasm is formed and are the precursors of the immune bodies which provide resistance to infection. This loss of amino acids undoubtedly contributes to the lowered resistance to infection of uncontrolled diabetics and the stunted growth of improperly treated diabetic children.

How does one determine the initial dose of insulin for a diabetic patient? At best the beginning dose is a guess. A safe dose with which

TABLE IV

METHODS OF INSULIN ADMINISTRATION

1. *For Regulation—*
   10 Protamine insulin
   5—5—5—Standard insulin — before meals
   Urinalyses— — four daily
   Feedings— — three meals and three supplementary feedings
   Standard Insulin— — dosage changed daily on the basis of the previous day's urinalyses
   Protamine Insulin— — dosage changed every three days as indicated by the 7 A.M. urinalysis
2. *Acidosis—*
   10 Protamine insulin

AM 7	AM 10	PM 1	PM 4	PM 7	PM 10	M 12	AM 4	
								Standard insulin

   Urinalyses— — every three hours
   Feedings— — every two hours
   Standard Insulin— — dosage changed every three hours on the basis of the color formula
   Protamine Insulin— — as above
3. *Coma—*
   50 Protamine insulin

50	40	30	20	20	20	
						Standard insulin

   Urinalyses— — every half hour
   Feedings— — glucose and saline intravenously
   Standard Insulin— — twenty units every half hour until urinalysis is "green" or blood sugar is 200 mg. per cent
   Protamine Insulin— — fifty units as the initial dose. After that once daily as in acidosis

to begin a known adult diabetic is ten units of protamine and five of standard insulin before breakfast and five units of standard insulin before lunch and supper. For young children the dose should be five units of protamine and three of standard insulin before breakfast and three units of standard insulin before lunch and supper. They are expressed respectively as $^{10}5-5-5$ and $^{5}3-3-3$. These doses are increased or decreased until the maintenance dosage is arrived at. The criteria by which the insulin is increased or decreased are the four daily urinalyses, which will be discussed later.

COMPLICATIONS

1. *Insulin Reactions*

Insulin reactions occur both with protamine and standard insulin. *Reactions with standard insulin* are apt to occur from two to five hours after injection. The treatment is ten to twenty grams of carbohydrate in the form of orange juice or sugar. If the patient is unconscious, 1 cc. of adrenalin chloride should be given subcutaneously, and glucose should be given intravenously or by stomach tube.

Reactions with protamine insulin usually occur from twelve to

twenty-four hours after injection. Because the reduction of the blood sugar is gradual over a relatively long period of time, the body becomes accustomed to the hypoglycemia and symptoms frequently do not appear until the blood sugar has fallen to 50 mg. per cent or lower. These reactions are more severe and prolonged than reactions due to standard insulin. The treatment is the same as for reactions due to standard insulin except that carbohydrate should be given repeatedly for a considerable time, ten to twenty grams every half hour for three or four hours or until the symptoms disappear.

2. *Acidosis and Coma*

Many good clinicians are now employing protamine insulin in the treatment of diabetic acidosis. In coma, an initial dose of fifty units is given followed by frequent and repeated doses of standard insulin in the conventional manner. In milder degrees of acidosis such as occur in acute infections, a morning dose of ten to twenty units of protamine insulin followed by standard insulin every two or three hours will add to the effectiveness of the standard insulin and shorten the period of acidosis. The dosage of either type of insulin must of course be controlled with frequent blood or urine analyses or both.

3. *Gangrene*

After acidosis and coma, the most important complication of diabetes is gangrene. This invariably occurs in the lower extremities and differs in no way from arteriosclerotic gangrene. In fact it *is* arteriosclerotic gangrene which occurs earlier in the diabetic than the non-diabetic.

A beginning gangrene of the toe will sometimes clear up with rest in bed and control of diabetes alone. Should the gangrene persist, surgery is indicated. An open sore of six weeks duration suggests the presence of osteomyelitis. X-ray of the toe will usually show bone destruction.

The question is whether to resort to radical or conservative treatment. In general, if the foot is warm with no pain and there is good pulsation of the arteries, conservative surgery is indicated. A moist gangrene with spreading cellulitis and lymphangitis up the leg calls for more radical surgery.

The management of the usual *acute surgical emergencies*, such as appendicitis, in a diabetic patient is a special problem. These cases are usually admitted in severe acidosis, and if possible two or three hours should be devoted to controlling this condition before operating. This

TABLE V

TREATMENT OF DIABETIC COMA

The immediate and indispensable need is fluid and sodium. These are more essential at first than insulin, because insulin is ineffective until the body fluid is restored.

Conditions to Combat:

A. Dehydration and peripheral circulatory failure (shock)

B. Acidosis

a. *Dehydration and Circulatory Failure:*

1. Physiological saline intravenously 1000-5000 cc.—glucose 5 per cent should be included in the first infusion.
2. Saline by rectum—6 ounces q.3.h.
3. Gastric lavage.
4. Clear broth, tea, coffee or water by mouth.
5. Keep patient warm.

b. *Acidosis:*

1. *Insulin*—one unit per kilogram of body weight as first dose. Then insulin is given in diminishing doses every half hour until the urine is "green" by Benedict's test or the blood sugar is 200 mg. per cent.

50—40—30—20—20—20

The urine is tested every half hour.

2. *Glucose* as indicated.

does not add to the surgical risk but reduces it, for these patients are often dehydrated and in shock, and measures directed toward overcoming the acidosis will at the same time combat the state of shock.

A blood sugar and CO_2 determination should be done at once. During the hour it requires to report on these, an infusion of 1000 cc. of saline is given with fifty grams of glucose and twenty-five units of insulin. After this the urine is tested every half hour, and twenty units of insulin given each half hour until the urine test is "green". In this way 105 units can be given in the two hours preceding operation, and the patient will be a much safer operative risk. A similar infusion after the operation with the same glucose and insulin is often helpful. As soon as fluids are allowed by mouth, the patient is placed on the fluid diet and insulin is given every two or three hours by the "color formula."

SIGNIFICANCE OF LABORATORY FINDINGS

The analysis for sugar of a single specimen of urine or even of a twenty-four hour specimen is of no value as a guide to insulin therapy. It merely proves that the patient has glycosuria at a particular moment or sometime during the twenty-four hours. What we want to know is after what meals is the patient spilling sugar? *In order to give insulin at the time it is needed and to avoid reactions, at least four daily urinalyses must be performed.* For the ambulatory diabetic it is sufficient to collect and analyze qualitatively a single specimen before breakfast and from

one to two hours after each meal. The before-breakfast specimen will reflect the effect of the protamine insulin given the previous day before breakfast. The forenoon, afternoon and evening specimens will detect the presence of glycosuria resulting from the corresponding meals and will indicate the necessary distribution of standard insulin if any is required. Before altering the insulin dosage a twenty-four hour record of these analyses is necessary. Therefore the *insulin dosage for any given day is determined by the urinalyses of the previous day.* It is essential to make these separate analyses every day while the insulin dosage of the patient is being adjusted. When the patient is stabilized they can be done every two or three days or even once weekly.

The urinalysis alone, then, provides a sufficient guide for controlling glycosuria or hyperglycemia. For detection of hypoglycemia, however, the urine analyses are only suggestive. With a sugar free urine hypoglycemia may or may not be present. A blood sugar analysis therefore *is* necessary to detect an impending reaction due to hypoglycemia. Indeed the chief function of a blood sugar analysis today is to prevent insulin reactions.

Again, as in urinalyses, a single blood sugar determination is of comparatively little value. In order to discover the times at which insulin reactions are most likely to occur, a *blood sugar curve* should be done. That means testing the blood for sugar several times during the day. At least four tests should be made: 7 A.M., 11 A.M., 5 P.M., 11 P.M.

This blood sugar curve need be done only once and that is when the patient has become regulated, so far as this can be determined by urinalysis alone.

In conclusion, I should like to emphasize that one needs to be familiar with only *one* diet on which to start any diabetic patient. This diet can be expressed by a prescription of three figures. One can even begin on the fluid diet, which is measured by the glassful. *Subsequent changes in the diet depend upon the weight of the patient.* The initial insulin dosage should be conservative. *Subsequent changes in the insulin dosage are determined by the four daily urinalyses.* Blood sugar tests are unnecessary while sugar is showing in the urine. When sugar disappears from the urine, the insulin dosage should be lowered enough to give an occasional "green" test. This will prevent insulin reactions. A blood sugar curve at this point is extremely helpful, but not mandatory.